United States Department of Agriculture

NRCS Natural Resources Conservation Service

Biology Technical Note

Indiana - October 2008 (ver. 1.0)

Wetland Macrotopography

The construction of macrotopographic features can be used to both restore and enhance wetlands where the natural topography of the site has been removed, as well as to create wetland habitats that did not previously exist. Wetland plant communities, and the wildlife species that use them, will benefit from utilizing the natural variability found on each wetland site, and from the creative use of the concepts found within this document.

WHAT IS MACROTOPOGRAPHY?


Jerry Roach - NRCS

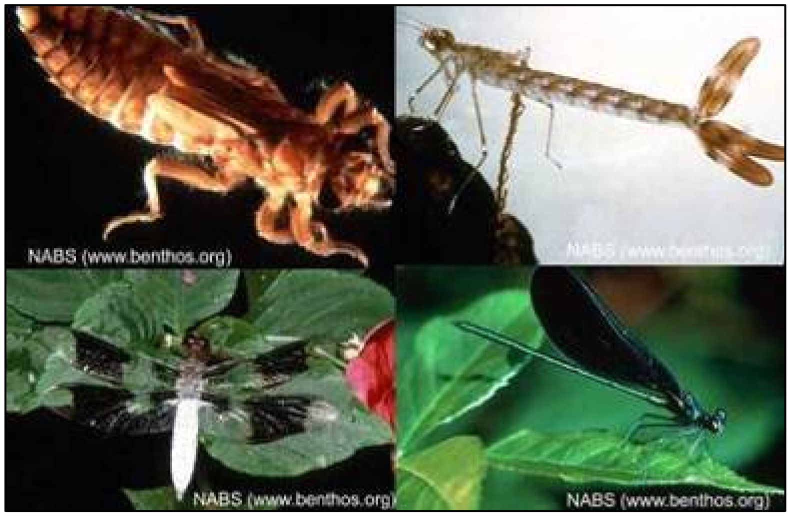
Background Undisturbed natural wetland systems in Indiana typically contain a complex of vegetative habitats. These "complexes" owe their existence to varying hydroperiods, the period of time during which a wetland is covered by, or saturated with, water. Hydroperiods are, in turn, greatly influenced by topographic relief and soil permeability. Topographic variation ranges from relatively shallow areas (microtopography) to deeper wetland habitats (macrotopography) and may include upland characteristics. Even small wetlands can exhibit a wide range of aquatic habitats if an adequate diversity of hydroperiods is present.

When wetlands are drained or altered for agricultural use, the land is often leveled and sloped to produce uniform crops. This process results in a loss of topographic diversity. When restoring wetland sites that exhibit uniform topography, returning the hydrology alone (through removing drainage tile or plugging drainage ditches) will often not result in establishing the diversity of wetland habitats that previously existed prior to disturbance. Restoring or creating microtopography and macrotopography increases the diversity of hydroperiods and results in a more complex wetland vegetative community, and consequently, a more diverse assemblage of wildlife species.

Microtopographic features are those areas with less than six (6) inches of water depth. While many examples are depressional in nature, others can form where land slopes are relatively flat, such as when small ridges back water into shallow pooled areas. Microtopography can often be seen in fields where shallow "sheet" water stands for short durations after a rain. Within the scope of this document, microtopographic features are assumed to be included when discussing macrotopography.

As indicated earlier, **macro**topographic features in undisturbed settings are often found in diverse groupings that create wetland "complexes." In most cases, these features are depressional in nature and have landscape positions that occur both in floodplains and on terraces. Basins range from approximately 0.1 acre to five (5) acres in size with depths running up to 30 inches. Variability in shape is common in natural wetlands. Some occur as simple circles, others as complex amoeba-like shapes, and still others as meandering linear features. Variations depend heavily upon the geomorphologic processes that created the wetland. The "upland" components that often occur in macrotopographic features consist primarily of mounds (circular or elliptical) and ridges (linear), and typically do not exceed 30 inches in height.

WHY IS MACROTOPOGRAPHY IMPORTANT?



Increased biological diversity is the primary benefit of macrotopography. As the number of hydroperiods increase, the more diverse a vegetative community becomes. Hydroperiod complexity provides the variability in water regimes necessary for the germination, establishment, and dispersal of many wetland plant species. Many amphibians, reptiles, waterbirds, and other aquatic wildlife species also depend on variations in depth, timing and duration to complete their life cycles. Consequently, wetland sites can become both a refuge for rare hydrophytic plants, and provide a great variety of habitats for wildlife.

Food In the spring, shallow, ephemeral wetlands warm up before larger, deeper bodies of water. The warmer waters produce significant amounts of protein-rich invertebrates; including snails, worms, fairy shrimp, midge larvae, spiders, backswimmers, diving beetles, dragonflies, and damselflies that make up an essential component of wetland food webs. These species provide important seasonal forage for shorebirds, waterfowl, non-migratory birds, and other wildlife. Organic debris (such as leaves, plant stems, and decaying woody material, along with roots, and tubers from aquatic vegetation) act as additional food sources, and provide substrates for the species described above. Consider designing wetlands that have a large portion of shallow area (less than 18 inches) where macroinvertebrate production is a priority.

Habitat The undulating landscape features created by the use of macrotopography help to diversify available wetland habitat. Swales, oxbows, potholes and other features provide varying hydroperiods from short-term ponding to seasonal and semi-permanent water conditions. Wetlands with multiple hydroperiods can support a variety of aquatic habitat types; including scrub-shrub, submergent, emergent, and floating-leaf communities (e.g., duckweed). A diverse wetland plant community benefits numerous species of wildlife including many fur-bearing mammals, waterfowl, shorebirds, wading birds, amphibians and reptiles.


Blanchard's Cricket Frog

The addition of low-level mounds or ridges can greatly increase the biological diversity of restoration sites when combined with basins. Variations in habitat mound design can provide escape areas, den sites, nesting opportunities, and plant diversity, as well as visual breaks within the wetland complex. Amphibians, for example, tend to have small home ranges. Thus, having shallow basins in close proximity to terrestrial habitats within the project area will support the greatest populations. See Habitat Mounds for further design guidance.

Vegetation In normal situations, existing seed banks in the soil and seed colonization from nearby wetlands and ditches can be relied upon to re-vegetate wetland sites. When developing a planting plan, only native vegetation should be used. Native plants generally provide the best overall habitat, are normally self-sustaining, and tend to be non-invasive. When possible, utilize plants collected or grown from material collected within a 200-mile radius from the site. See Indiana Natural Resources Conservation Service (NRCS) Biology Technical Note - Wetland Plantings for Wildlife for an extensive list of native wetland plant species beneficial to wildlife.

PLANNING

When developing macrotopographic features, assessment of the site prior to the restoration is critical. What would the site have looked like historically (i.e. prior to drainage)? In addition to wetlands, what other habitats (prairie, shrubland, woodland, etc.) would the site have included? The planner especially needs to consider the soil types located on the site, the target wildlife species (i.e. the primary species of concern), and the impact of natural succession on long-term management. U.S. General Land Office Surveys, historic photographs and aerial photography, topographic maps, and local remnant wetlands can be used to determine the appropriate features to include in the wetland project. For information on wetland management see Indiana Wetland Wildlife Habitat Management Standard.

Soils It is important for the planner to identify those portions of the site which have hydric soils or soils that will most likely respond to macrotopographic development. Look for soils that have low permeability, a restrictive under-lying layer, or high water tables. The Web Soil Survey can provide site-specific soils information, but there is also no substitute for a thorough on-site soils investigation.

Construction of macrotopography should be used with caution on sites with soils that are hydric *only because of flooding events.* These soils may not be appropriate if well-drained and not very frequently flooded. Floodplain sites along the lower portion of the Wabash River fall into this category. Since these soils are well drained, water remains in the basins only as long as the river elevations are high. Once the river levels fall, the basins go dry. In these cases it is unlikely that the habitat needs of the target species will be met, and it may be difficult to justify the expense of creating macrotopographic features. Restoration of native vegetation may be the only appropriate restoration measure. Similar issues may be found in Northern Indiana on large sites with drained organic (muck) soils. If it is unclear whether or not there is sufficient hydrology to maintain the needed water levels within the basin areas, a water budget should be calculated. Contact an NRCS Engineer and Soil Scientist for further guidance.

Amphibians and Reptiles The creation of habitat through macrotopography development can have a significant impact on amphibians and reptiles. Species such as frogs, toads, salamanders, newts, turtles, and snakes are collectively known as herpetofauna or more commonly "herps." Amphibian species are extremely variable in their habitat requirements. The timing and duration of ponding are especially important factors that dictate which amphibians will use a particular wetland. Most breeding occurs from May through August, with eggs hatching anywhere from four (4) to 20 days later. Complete metamorphosis into the adult stage may take an additional seven (7) weeks to three (3) months, with some species taking a year or more. Some species need as much as a year to develop, with a few species even over-wintering as tadpoles, thus requiring permanent water. Table 1 below (modified from Knutson, et. al.) is an example of the diversity in preferred breeding periods and guild associations from a study in Iowa and Wisconsin.

In Indiana, the target species of herps are those that complete their life cycle by early summer. Macrotopographic basins should therefore be designed to keep water available until at least mid-July. Because the process of wetlands drying out is also beneficial, most basins should not be designed to hold water permanently. Wetlands that dry out eliminate insect and vertebrate predators, allow seeds to germinate, and expose detritus to oxidation which releases nutrients. Macrotopographic basins that are completely dry by late summer or early fall can also normally be considered free of fish. This is important because fish are a primary predator of amphibians in all stages of development (larval, tadpole, and adult). In cases where basins are shallow, occasionally pools do retain water year round, but due to warm water conditions that create low oxygen levels, the basins still do not support fish populations. In general, sites with longer periods of ponding will have more predators and should be avoided if amphibians are the target species.

The addition of habitat mounds or ridges can also increase the use of restoration sites by reptiles. Landscapes with variation in vegetative structure, for example, can provide better thermoregulatory and predator-avoidance opportunities for snakes and lizards. Mounds may also create important nesting sites for turtles and hibernacula for reptiles.

Table 1[1]

		Breeding[2]		Nonbreeding[3]			Hibernation[4]		
Species	**Breeding period**	**Permanent water**	**Temporary water**	**Water**	**Forest/ litter**	**Open**	**Water**	**Forest/ litter**	**Ground**
American Toad	April - June	✓	✓		✓	✓		✓	
Blanchard's Cricket Frog	May	✓		✓				✓	
Bullfrog	May - July	✓		✓			✓		
Cope's Gray Treefrog	May - August	✓	✓		✓	✓		✓	
Eastern Gray Treefrog	May - August	✓	✓		✓			✓	
Fowler's Toad	March - August		✓			✓			✓
Green Frog	Mid-May - July	✓		✓			✓		
Northern Leopard Frog	April - June	✓	✓	✓		✓	✓		
Pickerel Frog	April - Mid-June	✓		✓	✓	✓	✓		
Western/Southeastern Chorus Frog	March - May		✓		✓	✓		✓	
Spring Peeper	March - Summer		✓		✓			✓	
Wood Frog	March - April		✓		✓			✓	

[1] Species that can successfully survive or reproduce in a habitat during the identified life-history phase are identified with a check mark (✓).
[2] Will breed in permanent water or temporary (ephemeral) ponds.
[3] Active, non-breeding portion of the year is spent in the water or along the water edges, in trees or forest litter, or in open, non-forested habitats (grasslands).
[4] Hibernation or estivation period is spent in or near water, in forest litter, or underground.

When planning a site for amphibian and reptile use, macrotopographic features should make up approximately 30-50% of the area (basin and mound areas combined). Typically, each acre of water creates an additional acre of mound habitat. When wetlands have a designed water level, such as those with levees and control structures, consider concentrating macrotopographic features in and near the shallow water reaches. These sites will have deeper, more permanent water near levees, so the intent is to create ephemeral wetlands that will go dry later in the year. Consider constructing both shallow and deeper macrotopographic features to provide a variety of hydroperiods. Adjacent uplands, especially forests, are also important to amphibians providing core habitat for many semi-aquatic and terrestrial species. Consider creating buffer areas around breeding wetlands of several hundred yards where feasible.

Marsh Birds Species such as rails and bitterns, some of the most endangered birds in Indiana as well as in the Midwest can benefit from the shallow water habitat provided by macrotopographic features. Key marsh bird habitat requirements include:

- Providing water depths ranging from 0 to six (6) inches
- Promoting emergent species such as sedges (Carex Spp.), cattails (Typha Spp.), bulrushes (Schoenoplectus spp.), rushes (Juncus spp.), and cordgrass (Spartina spp.)
- Providing an area interspersed with open water, mudflats, and a vegetation-to-water ratio of approximately 50:50

See Indiana FOTG Shallow Water Development and Management and associated Job Sheet for additional information on water management for marsh birds.

Shorebirds Shallow, ephemeral wetlands provide an abundance of aquatic invertebrates that are a critical food source for shorebirds during migration. Most shorebird species will utilize wetland habitats with water depths from 0 to three (3) inches, and will rarely forage in water depths greater than six (6) inches. Maximizing areas which provide conditions from mudflats through three (3) inches deep during spring and late summer will provide the greatest benefits for migratory shorebirds. See Indiana Shallow Water Development and Management and associated Job Sheet for information on water draw-downs.

Waterfowl Shallow basins also provide important invertebrate forage for waterfowl, particularly during spring migration when nutrient needs prior to nesting are high. Several species of dabbling ducks (e.g. mallards and blue-winged teal) will also utilize temporary wetlands for pair bonding and mating. Although these temporary wetlands may not contain water long enough to provide brood habitat in most years, the ponded areas serve an important function in distributing pairs across the landscape and allowing for courtship rituals. Visually isolating basins, or portions of basins, through irregular shaping will particularly benefit territorial species such as mallards. When combined with semi-permanent basins in close proximity, macrotopographic basins contribute to excellent wetland complexes for waterfowl breeding. See Indiana FOTG Shallow Water Development and Management and associated Job Sheet for information on water management.

Succession and Long-term Management Plant succession in wetlands is a natural process that can result in significant habitat changes over time. Common successional changes include the development of aquatic macrophytes (such as cattails), and encroachment of wetlands by trees and shrubs (especially Black Willow). Such changes can alter the wildlife species composition of wetlands over time by selecting for species that favor or can tolerate later successional stages. As a result, wetland diversity may be reduced as early successional species are lost.

Succession may work for or against the target wildlife species depending upon its habitat needs. The Northern Crawfish Frog, for example, requires herbaceous wetlands surrounded by grassland. With time, both herbaceous wetlands and upland grasslands in Indiana tend to evolve toward woody conditions. Without periodic disturbance, such as Prescribed Burning, to maintain these early successional habitats, Crawfish Frog populations would be expected to decline. On the other hand, Copperbelly Water Snakes prefer the shallow edges of shrubby swamps and shallow woodland ponds. Within limits, natural succession would be expected to provide habitat increasingly more beneficial to Copperbellies as wetlands mature with time.

Historically, natural disturbance regimes have included wild fires, floods, tornados, drought and beaver. Due to the ever increasing human-dominated landscape, many of these disturbances no longer function on a large scale. As a result, it may be necessary to mimic these conditions through the use of such methods as prescribed burning, disking, mowing, herbicide application and water draw-downs. The appropriate disturbance regime is one that will produce the type of habitat needed by the target species. Wetlands managed for shorebirds, for example, may need disturbance every several years to remove undesirable vegetation. Disking is used to convert plant biomass to a detrital base attractive to invertebrates, a key food source during shorebird migration. Regardless of method used, care must be taken to reduce possible negative impacts on non-target species. See Indiana NRCS Field Office Technical Guide (FOTG) Early Successional Habitat Development/Management Standard for disturbance method details.

CONFIGURATIONS

Basins There are no fixed or rigid configurations that macrotopographic features must have to provide wildlife habitat. However, basins that are irregular in shape will increase edge and provide additional cover for waterfowl and other wildlife utilizing the site. Some common shapes include those that mimick potholes, oxbows, and river meanders (see below).

Planners should choose shapes that are common to the landscapes found in the area, or should choose designs to maximize habitat for the target species. Designs with multiple lobes, for example, can provide visually-isolated basins which will benefit territorial species such as mallards. See Table 2 on design guidance for specific wildlife species.

Basin construction should result in side slopes with rough surfaces, an undulating bottom, and a ragged shoreline to promote a variety of micro-habitats (see picture on right).


Rough Surface Grading

Basin depth will have a significant effect on habitat qualities including the vegetative community and how long into the season water will remain. Shallow areas, for example, tend to vegetate quickly, while deeper areas may remain as open water. Basin depth should reflect the needs of the target species. Multiple depths increase habitat diversity. Designs also need to take into consideration the soil drainage qualities of the site. Basins form ephemeral wetlands that can hold water from only a few weeks to several months during the year. Consider constructing deeper basins where soils are in dryer drainage classes. Below are suggested configurations for basins of varying depths.

AERIAL VIEW **CROSS SECTION**

When one (1) depth is needed:

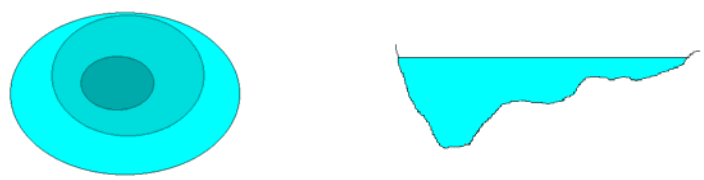
- one depth composes 100% of the area

When two (2) depths are needed:

- each depth composes 50% of the area

When three (3) depths are needed:

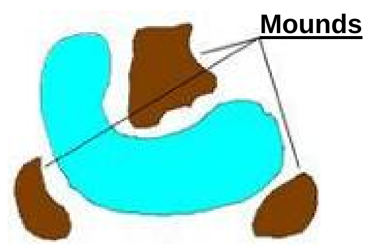
- deepest depth = 20% of the area
- middle depth = 30%
- shallowest depth = 50%



Habitat Mounds Fill material that is excavated from the macrotopograhic basins can be used to create upland habitat conditions (see Figure 1). By varying the height, shape, and location of mounds, a diversity of vegetative communities can be developed. Consider the following recommendations when designing habitat mounds.

- As much as possible, mounds should mimic the natural landscape. For example, if the site is located on the interior of a river oxbow, ridge and swale design may be appropriate (see Figure 2 on next page). When possible, place mounds in such a way as to increase meander distance across the wetland.
- Mounds should be seeded with herbaceous vegetation or planted to trees and shrubs as soon after construction as feasible. This will reduce the erosion potential, and limit invasion of aggressive plant species. Refer to Indiana NRCS Biology Technical Note - Wetland Plantings for Wildlife for acceptable grass, forb, shrub and tree species.

Figure 1



- In situations where geese are a nuisance, at least 30 feet should exist between the habitat mound and any water surface. The area between the mound and the water should then be planted with a vegetative barrier such as warm season grasses (taller species), trees or shrubs. This barrier will reduce the attractiveness of the mound as a nesting site.
- Side slopes should have a minimum slope of 6:1 where wave action is a concern, and to reduce visual impact.
- Where wetland sites have a designed water level, varying the elevation of mounds will produce different vegetative communities. For maximum diversity, design the mounds so that approximately one-third are six (6) inches to one (1) foot **below**, one-third are six (6) inches to one (1) foot **above**, and one-third are **at** the expected water elevation.
- Where restoration sites *do not* have a designed water level, such as in floodplains, habitat mounds can be used to direct water flow during flood conditions (see Figure 3). Mounds can range from six (6) inches to two (2) feet above average ground level, depending upon the flow impact desired.

Figure 2

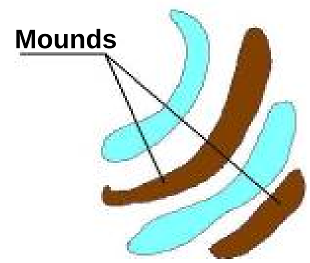
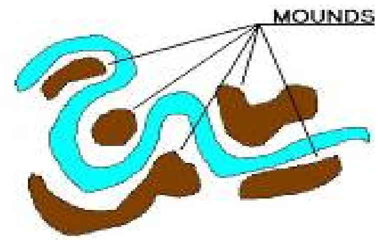
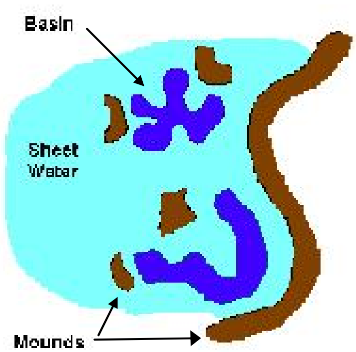


Figure 3



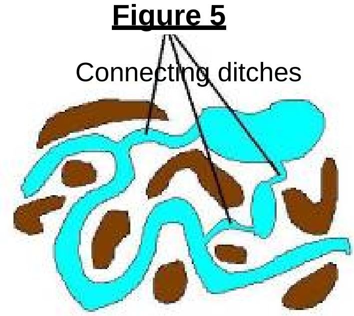
Sheet Water The creation of linear habitat mounds on gently sloping sites can be an efficient means of providing shallow, "sheet water" habitat (see Figure 4). The excavated material from a macrotopographic basin is used to form a low, meandering ridge on the down slope side of the basin(s). Typical heights for the mound range from one (1) foot to two (2) feet. By using the spoil in a creative manner, the total shallow water on a project site can be substantially increased. The impounded sheet water provides seasonal or ephemeral water for shallow feeders such as shorebirds, while the excavated basins provide longer hydroperiod wetland habitats. This method can also be utilized where wetland meadow conditions are desired.

Figure 4



Connecting Ditches Ditches of varying depths and widths can be constructed to provide habitat connectivity and escape routes from predators (see Figure 5). **Note:** In situations where amphibians are the primary species of concern, the connecting of ditches should be limited because access routes for predatory fish are created, particularly if connected to deeper, more permanent pools.

Figure 5



OTHER CONSIDERATIONS

Creative Borrowing Borrow areas for dikes or embankments can be incorporated into the development of macrotopographic features. Potholes, swales, meanders, and other shallow water habitats can serve as borrow areas for needed fill. Specific configurations should be based on the habitat requirements of the target wildlife species. For example, equipment operators can randomly fill scrapers across the entire wetland instead of taking it all from one area, leaving shallow, single-trip borrow sites that are used for foraging by migrating shorebirds. Borrow areas can also be used to provide additional hydroperiod diversity in wetland complexes.

Organic Materials Organic materials are crucial components of most natural wetland ecosystems. They are the foundation of food webs; the basis of many nutrient cycles; and provide habitat to many wetland dependent wildlife species. Organic materials are important in providing a slow and steady release of nutrients that provide long-lasting sources of energy to wetlands, in contrast to the sporadic and short-lived effects of most inorganic nutrients. When wetlands are converted to agriculture, most organic materials are destroyed, as well as the functions that they provide.

Organic material is derived mostly from dead vegetation and occurs in two forms. One of these is detritus, or small partially decomposed materials, such as leaves. Detritus decomposition provides a more rapid and seasonal release of nutrients to wetlands. The other form of organic material is termed large woody debris (tree trunks, branches, and root wads). Large woody debris provides low, but sustained levels of nutrient input into the wetland. In addition, large woody debris provides habitat structure for many species of wildlife. It offers perches for birds, loafing and basking areas for turtles, protective cover for amphibians, and attachment sites for amphibian egg masses. It also provides vertical structure to the wetland and greatly increases habitat diversity. Adding one or two properly anchored dead trees, sections of trunk, or root wads per acre will enhance the quality of most wetland restoration projects, as well as add to the aesthetics of the wetland. Trees removed as a part of site access or preparation can be used for this purpose.

Invasive Species Control It is essential to reduce the introduction of invasive plants during the restoration process. Purple Loosestrife (*Lythrum salicaria*), Phragmites (*Phragmites australis*), and Reed Canarygrass (*Phalaris arundinacea*) are examples of invasive plant species that will often move in after construction and soon dominate a site. To reduce the potential for invasives, consider practices such as cleaning equipment prior to construction and when traveling between restoration sites, establishing native plant species as soon as possible, and using cover crops during the establishment period.

Monitoring Simple monitoring of the site can verify that the plant and animal species targeted by the wetland restoration actually use the site. Landowners may find it interesting to learn about what type of creatures have inhabited their property after restoration. School groups or volunteers can also be engaged to do the same thing on lands accessible to the public. Monitoring tools designed for landowners are available from places such as The Land Stewardship Program in Minnesota.

REFERENCES

CRAWFORD, J.A., AND R.D. SEMLITSCH. 2007. Estimation of core terrestrial habitat for stream-breeding salamanders and delineation of riparian buffers for protection of biodiversity. Conservation Biology 21:152-158.

INDIANA DEPARTMENT OF NATURAL RESOURCES, Division of Fish and Wildlife, 402 W. Washington St., Indianapolis, IN 46204

KINGSBURY, B. A. Center for Reptile & Amphibian Conservation and Management, Indiana University Purdue University-Fort Wayne.

KNUTSON, M. G., W. B. RICHARDSON, D. M. REINEKE, B. R. GRAY, J. R. PARMELEE, AND S. E. WEICK. 2004. Agricultural ponds support amphibian populations. Ecological Applications 14:669-684.

KNUTSON, M. G., SAUER, J.R., OLSEN, D. A., MOSSMAN, M. J., HEMESATH, L. M., AND LANNOO, M. J. 1999. *Effects of Landscape Composition and Wetland Fragmentation on Frog and Toad Abundance and Species Richness in Iowa and Wisconsin.* Conservation Biology 13 (6), 1437-1446.

KNUTSON, M. G., J. R. SAUER, D. O. OLSEN, M. J. MOSSMAN, L. H. HEMESATH, AND M. J. LANNOO. 2000. Landscape associations of frog and toad species in Iowa and Wisconsin, USA. Journal of the Iowa Academy of Sciences 107:134-145.

KOLOZSVARY, M. B., AND SWIHART, R. K. 1999. *Habitat Fragmentation And The Distribution Of Amphibians: Patch And Landscape Correlates In Farmland.* Can. J. Zool.:1288-1299.

SEMLITSCH, R. D., AND J. R. BODIE. 1998. *Are Small, Isolated Wetlands Expendable?* Conservation Biology 12:1129-1133.

SEMLITSCH, R. D. 1998. *Biological Delineation of Terrestrial Buffer Zones for Pond-Breeding Salamanders.* Cons. Bio. 12:1113-1119.

SEMLITSCH, R. D. 2000. *Principles For Management of Aquatic-Breeding Amphibians.* Journal of Wildlife Management 64(3):615-631.

U.S.D.A. NATURAL RESOURCES CONSERVATION SERVICE, Central National Technology Support Center, Wetlands Science.

ZAPPALORTI, R. T. AND H. K. REINERT. 1994. Artificial refugia as a habitat-improvement strategy for snake conservation. Pp. 369-375. *In:* J. B. Murphy, K. Adler and J. T. Collins (eds.) *Captive Management and Conservation of Amphibians and Reptiles*. SSAR, Lawrence, KS.

Table 2: Macrotopography Design Guidance

Target Species		Excavated Depth (inches)	Size (acres)	Basin Side Slopes	Density (% of area restored)	Hydrology (minimum)	Comments
General Wetland Wildlife		6 - 30	0.5 – 1.5	8:1	10 -15%	July 15	Create variety in size & depth
Amphibians		6 - 12	0.1 – 3.0	20:1 or flatter	30 – 50%	July 15	Must remain fish-free
Aquatic Snakes and Turtles	**Seasonal 50%**	6 - 12	0.1 – 3.0	20:1 or flatter	30 – 50%	July 15	Sandy sites preferred for nesting turtles
	Permanent 50%	18 -30		8:1		Permanent	
Marshbirds (Bitterns, Rails & Herons)		6 - 18	0.5 – 3.0	20:1 or flatter	30 – 50%	Permanent	Create areas of saturation only to promote herbaceous vegetation (e.g. cattails)
Shorebirds		0 - 12	0.5 – 3.0	20:1 or flatter	Up to 100%	June 15: spring migration	
Waterfowl	**Feeding areas (50%)**	6 – 18	0.5 – 3.0	8:1 or flatter	10 -15%	May 30: spring migration July 15: breeding	
	Loafing areas (50%)	18 – 30	1.0 – 3.0	8:1			
Threatened & Endangered Species		Varies with species					Contact NRCS State Biologist for specific design criteria